marginal or incremental cost. Furthermore, the engineering estimates generated by the Incremental Cost Task Force were developed based on digital switching technology while the Perl and Falk estimate for local minutes served by electronic switches was based on the embedded technology in 1984-87 which was primarily analog. It is likely that the incremental costs of usage capacity for analog switching are higher than the incremental costs of usage capacity for digital switching.

IV. Conclusion

A reasonable estimate of the average incremental cost of terminating traffic using digital switches is 0.2 cents per minute. That estimate is supported by the engineering studies done with data for California and for Massachusetts and by one of the econometric models developed by Perl and Falk. Other reasonable econometric models using embedded cost data produce somewhat higher cost estimates. The cost is determined by peak period capacity and therefore the true cost is considerably higher than 0.2 cents/minute average during the peak period and is zero during the non-peak period.

INTERCONNECTION AND MUTUAL COMPENSATION WITH PARTIAL COMPETITION

Gerald W. Brock

Executive Summary

This paper examines the economic characteristics of various interconnection compensation policies when there are different levels of market power among the participants. When the market is composed of segments that are monopolized and segments subject to competition, interconnection and compensation arrangements are critical to the development of effective competition. A good interconnection policy will allow effective competition in the potentially competitive segments of the market while a poor interconnection policy will allow the monopolist of part of the market to extend its monopoly into potentially competitive sectors of the market. This paper shows that the theoretically correct policy is mutual compensation at cost based rates and that mutual compensation alone is insufficient to limit monopoly power. A desirable interconnection policy should be closely related to the theoretically correct policy and also take account of the practical problems of administrative feasibility and of definition and measurement of cost.

Several specific conclusions can be drawn from the analysis of this paper:

(1) If there are no regulatory controls on compensation for interconnection, the monopolist of part of the market can extend its monopoly power to the entire market;

(2) A mutual compensation policy without limits on the level of rates does not limit market power;

(3) The level of rates under a mutual compensation policy is unimportant if and only if the level of incoming and outgoing traffic is exactly balanced. Because traffic levels will rarely, if ever, be exactly balanced, the level of rates will be an important factor in the viability of competition;

(4) A mutual compensation policy with prices limited to the cost of service is the theoretically correct compensation policy. Mutual compensation with prices limited to the cost of service prevents the monopolist of part of the market from extending its market power to potentially competitive sectors of the market.

(5) Capacity charges rather than per minute charges allow attention to be focused on the cost of service at the peak load which is generally the real cost of service;

(6) "Sender keep all" is an administratively simple mutual compensation scheme with zero prices for terminating service. It is an attractive approximation to the theoretically correct policy of cost based prices when the incremental cost of terminating service is low.

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I. Introduction

This paper examines the economic characteristics of various interconnection compensation policies when there are different levels of market power among the participants. The conclusions of the analysis are:

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The issues of interconnection rights and the compensation to be paid for traffic exchanged among interconnected companies have played a crucial role in the development of competitive alternatives throughout the history of the telecommunication industry. Interconnection disputes began with the early efforts to expand market power in the mid-nineteenth century telegraph industry and have continued to the present.[1] Although the long history of interconnection controversies provides several models of possible solutions to interconnection issues, the problems have not all been solved. Past interconnection controversies have led to three different kinds of solutions:

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1 A brief summary of FCC efforts to devise appropriate interconnection policies for customer premises equipment, long distance service, and international service is contained in the appendix to this paper. For a more complete account see generally Gerald Brock, The Telecommunications Industry: The Dynamics of Market Structure (Harvard University Press, 1981) and Telecommunication Policy for the Information Age: From Monopoly to Competition (Harvard University Press, 1994).

(1) The customer premises equipment (CPE) model of zero interconnection charges;

(2) The long distance model of substantial one-way per minute interconnection charges;

(3) The international model of two-way per minute interconnection charges.

The emerging local competition requires an interconnection policy that will allow the efficient development of a "network of networks" in which customers have access to any combination of private and multiple public communications networks. The interconnection rules to and from monopoly networks should not be dependent on technology and should apply to both wireline and wireless services. This problem is more complex than past ones because there are no clear stationary boundaries across which interconnection must occur and because there will be a need for interconnection among companies with different and changing degrees of market power.

Both the CPE interconnection rules and the long distance provider access charge rules were developed in a context in which competitors were seeking interconnection with a monopoly public network. The international model provides a closer analogy to the emerging competition in which there may not be a clearly defined monopoly public network. Traditionally, international service has been provided jointly by the national carriers with neither national carrier allowed to provide service directly into the other carrier's country. The international accounting rate and settlement rate system is a mutual compensation arrangement in which the level of payment is negotiated by the carrier pairs and that level of payment is generally used for traffic in either direction. Whatever level of payment is chosen for carrier A to compensate carrier B for terminating traffic received from A is generally the same level used for carrier B to compensate carrier A for terminating traffic received from B.

The mutual benefit and mutual compensation aspects of the international model make it appealing as a framework for interconnection of a wide variety of networks in the future. However, even the increasingly competitive future situation is likely to retain areas of monopoly power, and the international model has encountered difficulties in dealing with different levels of market power among the participants in the bargain.

With the mutual compensation approach, the actual level of payments makes no difference <u>so long as traffic is exactly balanced in both directions</u>. For example, suppose carriers A and B each originate 100 minutes of traffic to be terminated by the other. If the compensation rate for termination is \$1, each pays the other \$100, while if the compensation rate is \$10, each pays the other \$1000. In either case the payments exactly cancel out.

If traffic is unbalanced, the compensation rate does matter. If the more competitive carrier originates more traffic than it terminates (as has been the typical pattern in international communications), then a high mutual compensation rate favors the monopolist. For example, suppose low prices in competitive market B cause companies to originate 100 minutes while high prices in monopolized market A cause companies to only originate 50 minutes. Then a compensation rate for termination of $1 causes a net payment from B to A of $50, while a compensation rate of $10 causes a net payment from B to A of $500. Evan Kwerel's analysis of the international market concluded that with a net traffic outflow toward the monopolist, the mutual compensation principle does not limit the monopolist's ability to extract profit from the more competitive partner: "When the net traffic flow is out of the U.S., as with international MTS, ... U.S. carriers are making net payments to the PTT. The PTT can extract the same total revenue from U.S. carriers regardless of the terms for dividing the accounting rate by demanding a sufficiently high accounting rate."[2]

Because lower prices for calls originating in the competitive U.S. market than for calls originating in the generally monopolized foreign markets have created a net traffic outflow from the U.S., compensation rates above cost have created an increasingly large balance of payments

2 Evan Kwerel, "Promoting Competition Piecemeal in International Telecommunications," FCC, OPP Working Paper 13 (December 1984), p. 49.

deficit. Net outflow from U.S. carriers to foreign carriers increased by a factor of 10 between 1980 and 1992, rising from $347 million in 1980 to $3,344 million in 1992.[3] The rising balance of payments deficit due to compensation rates above cost has led to extensive consideration at the FCC and other U.S. government agencies of ways to attain the "objective of promoting lower, more economically efficient, cost-based international accounting rates and calling prices."[4]

II. A Framework for Analyzing Interconnection Issues

Today's communications marketplace is a hybrid with market segments of robust competition (no barriers to entry) and market segments of little or no competition (extensive barriers to entry). The problem is to create an interconnection policy that will be feasible across a wide range of situations, including different cost situations, different technologies such as wired and wireless, and different degrees of market power. The interconnection arrangements should be flexible enough to meet changing circumstances rather than having the rigidity of the existing prescribed access charge structure.

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3 FCC, Industry Analysis Division, "Trends in Telephone Service," (May 1994), Table 31, p. 48.

4 "In the Matter of Regulation of International Accounting Rates," CC Docket 90-337, 6 FCC Rcd. 3552 (1991) at 3552.

The interconnection and compensation arrangements are critical for the development of competitive benefits when there are some market segments with market power and other market segments subject to potential competition. Assume that customers can be divided into two groups: a set A for which entry is very difficult and a set B for which entry is easy. The division of the customers into two classes creates four different types of traffic:

(1) traffic among the customers in A, designated AA traffic.

(2) traffic originating from a customer in A and terminating in a customer of B, designated AB traffic.

(3) traffic orignating from a customer in B and terminating in a customer of A, designated BA traffic.

(4) traffic among the customers in set B, designated BB traffic.

The significance of interconnection policy depends upon the relative sizes of AB and BA traffic compared to AA and BB traffic. If, for example, A and B represent very different kinds of customers with no desire to communicate between the groups, then AB and BA would be very small and interconnection policy would be largely irrelevant. In that specialized case, there could be one system serving A customers and a completely separate system serving B customers with no loss in efficiency. However, in the more normal case, the division of customers between A and B is a function of geography and customer characteristics that do not affect their desire to communicate with each other. Thus AB and BA represent substantial streams of traffic and it is necessary to have interconnection among the systems in order to promote efficiency.

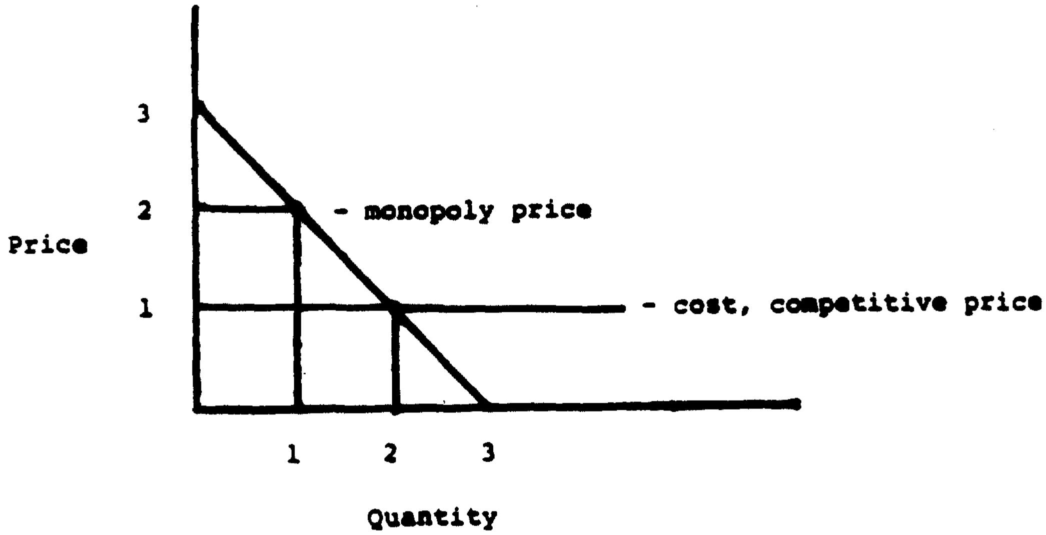
A second factor that affects the importance of interconnection policy is the existence of fixed costs per subscriber compared to costs per unit of traffic. If there are no fixed costs per subscriber (any number of subscribers can be served at the same total cost so long as the total traffic carried is the same), then interconnection policy is less important than when there are fixed costs per subscriber. With no fixed costs per subscriber, it may be efficient to serve the different traffic streams with different systems (one system for BB traffic and another for BA traffic, for example). With fixed costs per subscriber, the subscriber must choose the system that best fits that subscriber's needs. Limitations on AB and BA traffic may make a separate system for BB traffic infeasible with fixed costs per subscriber, but not with only usage costs.

The remainder of this paper examines some of the interconnection issues with a "toy model" consisting of a total universe of six subscribers who desire to communicate with each other. The simplified model allows explicit solutions to be worked out in a way that is more obvious than either more realistic simulation models or mathematical formulations. However, the results are quite general and not dependent upon the specific characteristics of the simple model presented.

Assume there are six individuals, designated 1 through 6. Each person *i* has a linear demand curve for communication with each of the other five individuals shown in Figure 1. Each person demands 3 calls per time period with each other person when the price is zero per call, 2 calls per time period when the price is $1 per call, 1 call per time period when the price is $2 per call, and at a price of $3 per call is priced out of the market. If all six people are connected in a network, the total demand of

FIGURE 1

One Person's Demand Curve for calls to one other person

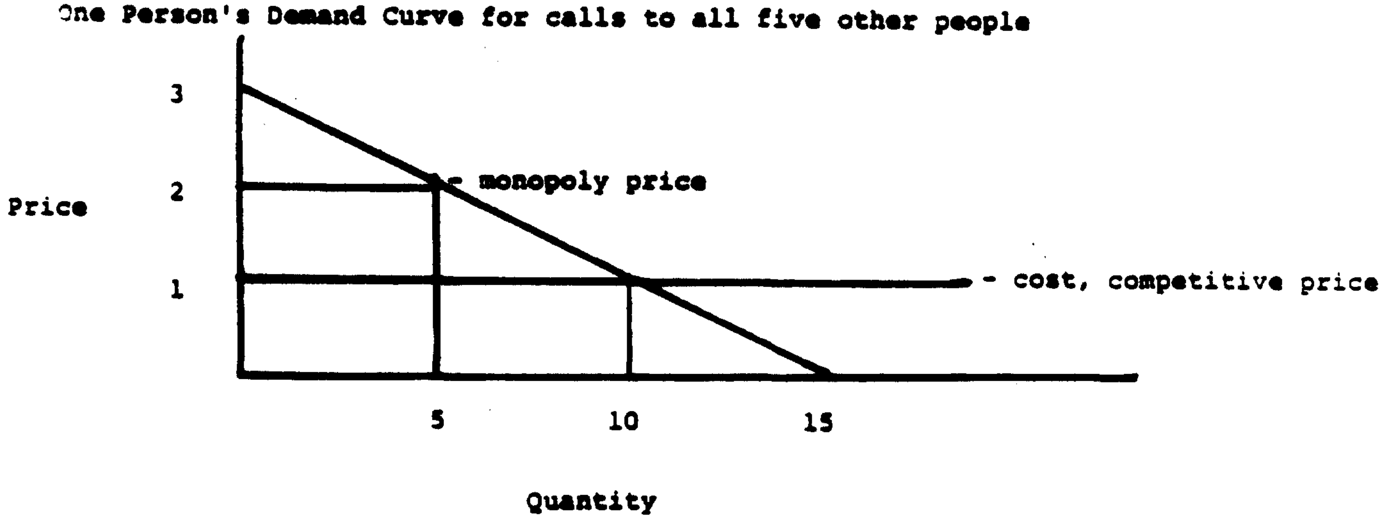


person *i* for communication with the other five individuals is simply the sum of *i*'s demand for communication with each of the individuals as shown in Figure 2; person i has a demand for 10 calls per time period to the entire network at a price of $1 per call because person i desires to make two calls to each of the other five people at that price.

Assume that the cost of providing each call is $0.5 for each call originated and $0.5 for each call terminated. Thus the usage cost per call is $1 for each call carried entirely over one network and is $.5 for each call originated or terminated on the network.[7] There are no interconnection

FIGURE 2

One Person's Demand Curve for calls to all five other people



costs for multiple networks. That is, the real interconnection cost (but not necessarily the price) of interconnection is zero, though there is a real cost to the networks of terminating traffic provided by other networks.

With a cost of \$1 per complete call, the competitive price is \$1 yielding a quantity demanded of 2 per person-pair or of 10 calls per person to the other people on the network. The pure monopoly price is \$2 per complete call yielding a quantity demanded of 1 per person-pair or 5 calls per person to the other people on the network, as illustrated in Figures 1 and 2.[5] The monopoly price of \$2 per call yields a monopoly profit of \$1 per person-pair, while the competitive price of \$1 per call is equal to the cost and yields no net economic profit. With no fixed costs per subscriber, the potential monopoly profit from the network is \$30 (6 subscribers each making one call per time period to 5 other subscribers and generating a monopoly profit of \$1 per call).

Assume that the incumbent is the only possible provider of service to the first three subscribers while anyone can serve the remaining three subscribers. That is, subscribers 1, 2, and 3 are in the set A of monopolized subscribers

5 The person-pair inverse demand curve is $P = 3 - Q_{ij}$ where P is the price per call and Q_{ij} is the number of calls from person i to person j. The corresponding marginal revenue curve is $MR = 3 - 2Q_{ij}$. Using the monopoly profit maximizing condition of marginal revenue equals marginal cost when marginal cost equals 1 yields a quantity of 1 and corresponding price of 2 for each person pair.

while subscribers 4, 5, and 6 are in the set B of competitive subscribers. There is no regulation of the prices that the monopolist can charge its own customers. In a standard market with no network externalities, these conditions would allow the monopolist of the A customers to extract monopoly profits from them, but would not allow the monopolist to extend its monopoly power to the B customers. The network nature of telephone service makes it possible for the monopolist to extend its power to the B customers through control of interconnection conditions. The best that an interconnection policy can do is to restrict the monopoly power to the set A. That is, a good interconnection policy will reduce potential monopoly profits from $30 (the level at which all customers pay monopoly prices) to $15 (the level at which A customers pay monopoly prices and B customers pay competitive prices). No interconnection policy in itself can reduce the monopoly power over A customers, but a poorly functioning interconnection policy can allow the monopoly to be extended to part or all of the calls from the potentially competitive B customers as well. The monopoly extension occurs because a poorly functioning interconnection policy limits the ability of carriers in B to terminate calls on A's monopoly network and may make competition in B infeasible.

The following examples assume for simplicity that only linear pricing (a specified charge per call) may be used, though the price may be different for different classes of customers. Allowing more complex pricing plans (such as multiple combinations of fixed and usage charges) would produce different numbers but would not yield different conclusions.

III. No Fixed Costs per Subscriber

With no fixed costs per subscriber, the monopolist of A sets a price of $2 for AA calls (originating and terminating among customers of A), while the competitors that serve B set a price of $1 (equal to cost) for BB calls. The interconnection conditions determine the prices for AB and BA calls.

A. No Required Interconnection

If there is no interconnection requirement, A can monopolize the AB and the BA calls along with the AA calls, but cannot monopolize the BB calls in the absence of fixed costs. The monopolist of A can guarantee itself access to the customers of B either by purchasing access from a current supplier or by establishing its own affiliate to serve B. Competition in B means that no one can charge more than $.50 (the cost of termination) for terminating calls from A; otherwise, another competitor would offer to do it more cheaply. A will maximize profits from its monopoly by charging a price of $2.00 for AB calls (yielding a net profit of $1 per call after paying its own expenses of $.50 for originating and the competitive termination fee of $.50), and charging an access fee of $1.50 for BA calls.

Because B is competitive and the cost of originating calls is $.50, the B competitors will charge $2.00 for BA calls, just equal to their total cost of $.50 for origination and $1.50 for termination.

Under these conditions, the equilibrium is full monopoly pricing of $2.00 per call for AA, AB, and BA calls (each yielding a net profit above cost of $1.00 per call) and competitive pricing of $1.00 per call for BB calls (equal to the cost of service and thus yielding a net profit above cost of zero). The monopolist of A will make a profit of $24 ($1 each on the 24 total calls made at a price of $2.00 for AA, AB, and BA calls). There will be 12 BB calls at a price of $1.00 each, yielding a net profit of zero. If there had been a complete monopoly of both A and B, the potential profits in this situation would have been $30 (including the $24 realized profits and the $6 unrealized profits that would have come from pricing BB calls at the monopoly level of $2.00 each). The monopolist of half of the subscribers makes 80 percent of the total possible monopoly profits because of its control of interconnection conditions. In other words, bringing competition to half of the subscribers only reduced monopoly power by 20 percent.

B. Required interconnection with mutual compensation

In this situation, companies are required to provide interconnection with each other, and are required to charge and receive the same rate. That is, whatever one company charges for terminating calls must be the same rate it pays the other company for terminating calls. As in the first case, the monopolized AA calls will be charged at the pure monopoly rate of $2.00 and the competitive BB calls charged at the cost-based rate of $1.00 each. Now, however, the situation above in which A charges $1.50 for terminating calls received from B and pays $.50 to B for B's service in terminating calls received from A is disallowed because the rates must be the same.

While this case appears to reduce A's monopoly power, it generally does not affect it at all. Only in the very specialized case of exactly balanced traffic does mutual compensation without control of rates limit A's monopoly power. More generally, A can use its control of the actual compensation rate together with traffic imbalances to maintain its monopoly power. Because anyone can enter the service of B, the monopolist of A can establish an affiliate that serves B. The monopolist of A can then set a compensation rate that allows it to maximize profits in both the A and B market segments while making it infeasible for competitors in B to serve traffic from B to A. For example, the monopolist of A could set a compensation rate of $2.00 for terminating any traffic received from A and also agree to pay $2.00 for any traffic delivered either to its own affiliate or to other competitors in B. For a carrier in B that is not affiliated with the monopolist of A, the competitive price for traffic from B to A is then $2.50 ($.50 cost of originating the traffic plus $2.00 paid to the monopolist of A for terminating the traffic). However, the affiliate of A will set a price of $2.00 for B to A traffic because that is the profit maximizing price for the total company. The difference in pricing comes because the non-affiliated company sees the $2.00 payment to the monopolist of A as a real cost that must be recovered in the price charged, whereas the affiliated company sees the $2.00 payment as an internal company transfer that does not affect the real cost of doing business. For the affiliated company, the size of the payment affects which entity reports the profits, but it does not affect the total profit of the combined enterprise.

Because the affiliated company prices B to A traffic at $2.00 while the non-affiliated companies price the same traffic at $2.50, customers will choose the affiliated company. Once the affiliated company monopolizes the B to A traffic, it will naturally receive the A to B traffic as well. The profit maximizing solution for the monopolist of A and its affiliate in B is consequently to set a high compensation rate (any rate above $1.50) and to price all traffic at the monopoly price of $2.00, even though some of the traffic will show high profits and some will show losses if the specified compensation rates are taken into account. The total profits of the monopolist of A and its affiliate remain at $24 or 80 percent of the total potential just as in the case of no required interconnection. Customers pay the same prices as in the case of no required interconnection. The requirement for mutual compensation has not reduced the monopoly power at all.

This case illustrates the problem with relying only on a structural solution such as mutual compensation without control of the actual rates paid. Consider, for example, the case of a local exchange company interconnecting with a wireless services provider. Assume that the local exchange company is the only service provider for some customers but that the wireless service can be provided on a competitive basis. If the local exchange company has a wireless affiliate, it can maximize the total profits of its enterprise by setting a high mutual compensation rate. Payments to the local exchange company from the wireless companies are an internal transfer for the affiliated company but a real cost for the unaffiliated company. So long as the competitive wireless companies send more traffic to the local exchange company than they receive from it (as is generally the case), then a high mutual compensation rate disadvantages the non-affiliated carriers and could make it impossible for them to compete with the affiliated carrier. Thus if the monopolist of part of the market is not restricted in its ability to enter potentially competitive sectors of the market, mutual compensation without control of rates fails to provide the consumer benefits of competition.

C. Mutual Compensation at Cost

In this case, each party must compensate the other at identical rates, but the rates are limited to the actual cost of providing terminating service. Using the model developed above, the compensation rate for termination service in this case would be $.50 per call.

The competitors of B will provide BB traffic at the competitive price of $1.00. They will also provide BA traffic at the competitive price of $1.00, composed of $.50 incurred as their own cost for originating traffic and $.50 incurred as an access payment for terminating traffic. The monopolized customers of A will pay the monopoly price of $2.00 per call for AA traffic and will pay the monopoly price of $2.00 per call for AB traffic.

With cost-based interconnection charges, the opening up of 50 percent of the customers to potential competition reduces monopoly power by 50 percent. This contrasts with the case of mutual compensation without control of rates in which the monopoly power was only reduced by 20 percent. The cost-based interconnection effectively eliminates the network externality and makes the telephone network similar to a standard market. The two "products" of service to A and service to B can be sold separately in accordance with their respective market conditions. The cost based interconnection effectively severs the tie between the products, and removes it from the context of network externalities, vertical integration, or tightly complementary products.

The use of cost based interconnection also makes the monopoly power and actions of A very visible. In the preceeding case, the customers of A and B were charged the same price, leaving some potential doubt as to whether A was truly exerting its monopoly power. In this case, the customers of A are charged twice the rate of the customers of B even for the same physical call and therefore the monopoly actions of A are clear.

IV. Fixed costs per subscriber

Assume a fixed cost of $2 per subscriber. That is, any company that chooses to serve a particular subscriber incurs a cost of $2 even with no traffic, and incurs the same costs as above ($.50 originating and $.50 terminating) for each call carried. Fixed costs per subscriber have been a standard part of telecommunication history, and many of the existing universal service provisions are concerned with defraying the fixed costs per subscriber. In telephone language, the previous section assumes non traffic sensitive (NTS) costs are zero and this section assumes NTS costs are significant.

A. No Required Interconnection

With no required interconnection, a company choosing to serve the potentially competitive customers in set B can only be certain of the BB traffic (the traffic among customers of B). A separate network to serve only BB calls at a price of $1 per call as in the previous section is no longer viable because of the fixed cost per subscriber. A company desiring to serve only BB traffic must charge enough to pay the fixed cost of $2 per subscriber as well as the usage cost of $1 per call. The only way to do that with linear pricing is to charge the BB customers the monopoly usage price of $2 per call, yielding a profit above usage costs of $2 per person which is just enough to cover the fixed cost of serving the person. That provides no advantage to customers of BB compared to accepting service from the monopoly and therefore the separate network for BB customers alone is not feasible.

So long as interconnection is not required and the monopolist of A recognizes that service to BB alone is not viable, the monopolist of A will refuse connections. That allows A to monopolize the entire market. A's ability to extend its monopoly power from AA and AB traffic to include BA traffic in the case of no fixed costs now allows A to extend its market power to BB traffic as well.

Alternatively, A can accomplish the same thing as refusing to interconnect by setting a high fee for interconnection. If A charges $1.50 for traffic terminating on its network, customers of B are indifferent between taking service from A or from B and A makes a profit of $1 per call either directly from the customer or from the interconnection fees charged to B. The difference from the previous case is that A can now also make a profit of $1 per call from BB calls because it is infeasible to pay the additional fixed cost of having a separate network only for BB calls. The combination of fixed costs and no interconnection requirements means that the potential competition for half of the customers does not reduce total monopoly power at all. The customers pay full monopoly prices for all calls, just as if there were no possibility of entry for any customers. Total potential monopoly profits are less in this case than before because of the fixed cost per subscriber. The potential monopoly profits of $30 in the previous case are reduced by $12 (fixed cost of $2 per subscriber times 6 subscribers) to $18. However, the monopolist of A now makes 100 percent of the potential monopoly profits rather than 80 percent as in the previous case.

B. Required interconnection with mutual compensation

A will demand a high rate (above $1.50 per call) as a termination fee for any traffic received from B and will agree to pay the same rate for any traffic sent to a company serving B. However, A will also establish an affiliate in B and will send as much traffic as possible to its own affiliate. As in the case of no fixed cost, this transfers profit from the monopolist of A to A's affiliate serving B customers, but it does not reduce prices for customers or reduce total monopoly power. Because of the fixed costs per subscriber, no company independent of the monopolist of A will find it profitable to serve any part of the B market. The interconnection fee established by A makes it unprofitable to serve B customers without return traffic, and unaffiliated companies serving B cannot be certain of the amount of return traffic they will receive. The fact that unaffiliated companies see the interconnection fee as a real cost while the affiliated company only sees it as a transfer payment among parts of the company allows A to manipulate the fee to disadvantage its competitors. Thus even with half of the market open to competition and required interconnection with mutual compensation, A can monopolize the entire market by controlling the level of the interconnection fee.

As in the case of no fixed costs, the key issue in this case is that A is able to establish an affiliate to serve B, but competitors in B are not able to establish an affiliate to serve A. Consequently, A and its affiliate can pay any necessary fee to each other and recognize the profit in whichever place is convenient. So long as A can establish an affiliate in B, there is no difference between the case of required interconnection with mutual compensation and the case of no required interconnection. In both cases, the monopolist of A can entirely monopolize the market.

C. Mutual Compensation at Cost

With cost-based mutual compensation, the monopolist of A is no longer able to extend its monopoly power into the B